MULTI-RESOLUTION ESTIMATION OF BOTTOM ACOUSTIC PROPERTIES THROUGH MODAL INVERSION

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LONG-TERM GOAL

To develop an inversion procedure which will estimate the bottom acoustic properties with sufficient resolution and enable prediction of acoustic field over a range of frequencies.

SCIENTIFIC OBJECTIVES

Investigate the usefulness of wavelets in determining the bottom acoustic properties at different scales using modal eigenvalues at different frequencies as input data.

APPROACH

The use of modal eigenvalues for estimating the compressional wave speed profile in sediments has been well documented[1]. In our earlier work, box car functions were used to represent the compressional wave speed profile in the sediments. In this study, I explore the use of basis functions derived from wavelets to represent the unknown compressional wave speed profile. Use of these basis functions will help in estimating the compressional wave speed profile at different scales.   The wavelet $\psi_{\lambda,u}(t)$ represents a family of functions $\frac{1}{\lambda}\psi\left(\frac{t-u}{\lambda}\right)$ where λ is the parameter that controls the dilation or contraction of the function and u the translation of the function. For certain class of wavelets, the functions $\psi_{\lambda,u}(t)$ are orthonormal.   Using this property any function $f(t)$ can be approximated to a high degree of precision by a linear combination of the wavelets. The unknown function $c(z)$ which represents the compressional wave speed in the sediments can then be approximated to scale m by the relation

$$A_m c(z) = \sum_n a_n^m f_n^m(z)$$

where $f(z)$ called the scaling function is derived from the wavelet function $A_m c(z)$ is the approximation of $c(z)$ to scale m. Inserting this expression into the inversion algorithm,

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we obtain the coefficients a_n^m which are then used in the equation above to obtain the compressional wave speed profile at scale m.

RESULTS

The scheme was tested with synthetic data. The compressional wave speed profile in the sediment and the water column are shown in Figure 1. For this model and assuming a known constant density in the sediments, the modal eigenvalues at 50 Hz, 100 Hz and 200 Hz were obtained using KRAKENC[2]. These eigenvalues were used as input in the inversion algorithm and the compressional wave speed in the sediment was estimated at different scales. Haar and Daubechies wavelets were used in the analysis. The results of reconstruction showing the results for different scales are presented in Figure 2. The maximum resolution attainable is related to the highest frequency of the source and is approximately half the wavelength at this frequency. It was also seen that the estimated model was able to predict the field up to 1000 Hz with good accuracy though the estimates were obtained in the frequency range 50 Hz to 200 Hz.

IMPACT/APPLICATIONS

Multi-resolution method permits us to obtain the best possible estimate of the bottom properties that the data will support. It can be used to look selectively at different regions and obtain estimates with high resolution close to the water sediment interface and estimates with coarser resolution at deeper depths.

REFERENCES

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2. M. B. Porter, " The KRAKEN normal mode program," SACLANT Undersea Res. Center Memo (SN-245) and NRL Report 6920,1991.
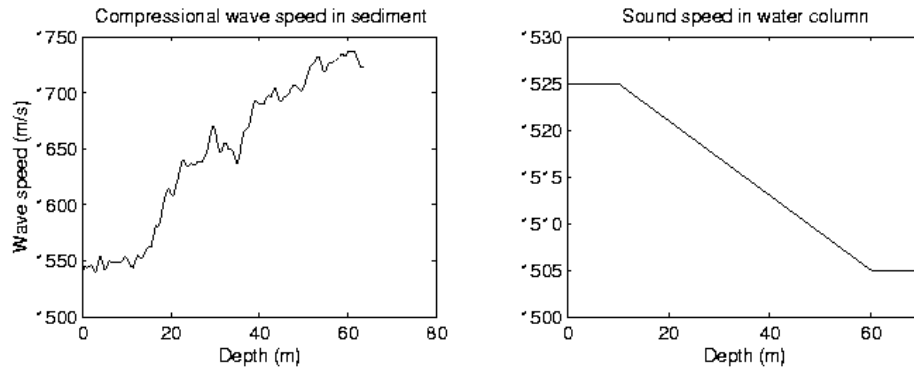
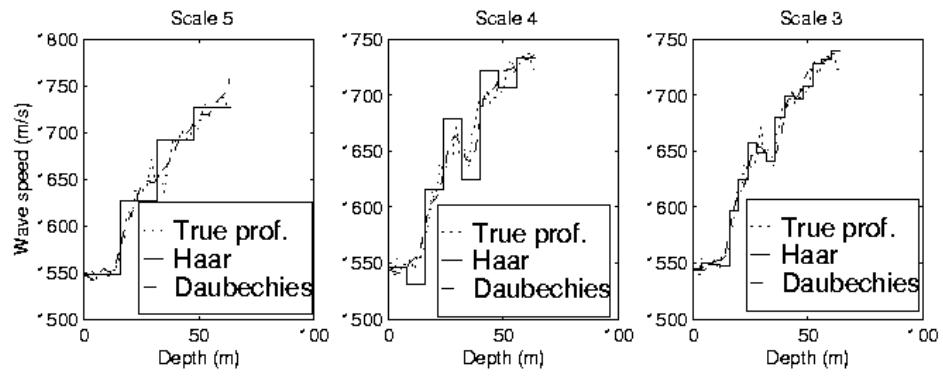Figure 1: Compressional wave speed profiles in water column (left) and sediment (right).

Figure 2: Reconstructed and true profiles at different scales using Haar and Daubechies wavelet.